Student's mathematical concept understanding ability in the material of functions of class XI of SMA Islam Sabilurrosyad Gasek Malang

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Abstract

This study aims to analyze student's mathematical concept understanding ability on function material in class XI of SMA Islam Sabilurrosyad Gasek Malang in the 2024/2025 Academic Year. The research method used is a qualitative approach with a case study. Data were collected through interviews with teachers and students, classroom observations, and concept understanding tests. Interviews were conducted to explore factors that influence student understanding, observations were used to see student interactions with the material and teaching methods applied, and tests were used to identify student misconceptions. The collected data were analyzed to determine the main themes related to student's difficulties in understanding the concept of functions and the misconceptions that occurred. The study results showed that there were difficulties for students in understanding the concept of functions, which were caused by factors such as ineffective teaching methods and a lack of practice. Based on these findings, it is recommended that teachers improve their teaching methods and provide more varied exercises to improve student understanding. The implications of this study show the importance of an interactive and contextual teaching approach in conveying mathematical concepts. As a practical recommendation, teachers are advised to use visual learning media and provide constructive feedback to help students build a deeper understanding of concepts.

Keywords: mathematical concepts, contextual teaching, student misconceptions, function, case study.

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INTRODUCTION

Conceptual understanding is key in learning mathematics. Students with strong conceptual understanding can reason about mathematical concepts, apply them to new situations, and solve non-routine problems. This depth of understanding is crucial for connecting classroom learning to real-world scenarios and for long-term retention of knowledge (George, et.al., 2024). A concept is an idea formed based on the same properties of a set of objects. Student's inability to understand concepts can lead to misconceptions, which in turn result in difficulties in solving mathematical problems. Many students are unable to understand even the simplest part of mathematical material, so they consider mathematics to be a complicated science (Andriani et al., 2017).

Mathematics is one of the disciplines that is very important in forming student's coherent and analytical skills. There is a strong positive relationship between student's analytical thinking abilities and their mathematics performance. Analytical thinking skills can account for a large portion (up to 72.3%) of the variation in student's math achievement, highlighting the importance of fostering these skills to improve academic outcomes in mathematics (Nkepah, 2024). Mathematics itself can be a science that reflects on reasons regarding forms, structures, quantities, and interrelated concepts. Mathematics can be a coherent design of thought and organization, and can be a dialect that uses carefully defined terms.

Thus, arithmetic is taught at all levels of education, from elementary school to college. However, many students consider science a difficult subject, especially because of the complexity of the concepts that must be understood.

Students often bring initial conceptions that can affect their understanding of new material. Misconceptions that occur can hinder the learning process and further understanding. Therefore, it is important to evaluate student's conceptual understanding so that teachers can identify the difficulties faced and design more effective learning strategies (Azizah et al., 2020). Concept-based instruction leads to deeper understanding, critical thinking, and the ability to transfer skills across different mathematical topics and contexts. Students become more engaged and are better able to integrate and apply their knowledge (Mahmoud et.al., 2019).

Achieving conceptual understanding is not always easy because each individual has different abilities. This is also a concern at SMA Islam Sabilurrosyad Gasek Malang, where many students have difficulty understanding the mathematics material, especially on the topic of function forms. Based on interviews with students and teachers, it was found that errors in the delivery of material by teachers caused student's difficulties in understanding this concept. Lack of practice is also a factor that hinders their understanding (Giawa et al., 2022). Errors in how teachers deliver mathematical material can significantly contribute to student's difficulties in understanding mathematical concepts. When teachers do not effectively address or use errors as learning opportunities, students are more likely to develop misconceptions and struggle with conceptual understanding. Traditional teaching often focuses on correct solutions and avoids discussing errors. However, incorporating error analysis where students identify, explain, and reflect on mistakes leads to a deeper and more comprehensive understanding of mathematical concepts. When teachers neglect this, students miss valuable opportunities to confront and resolve their misconceptions (Amaral & Mazzi, 2024).

In addition to internal factors such as student's initial abilities and learning styles, external factors such as the learning approach and media used also play an important role in shaping conceptual understanding. Many teachers respond to student errors in a teacher-centered way, focusing on correcting mistakes without engaging students in the reasoning behind them. This approach can leave gaps between the errors identified and those actually addressed, limiting student's conceptual growth (Larsson et.al., 2022). Meinarni & Nuryadil (2022) showed that students with high initial mathematical abilities tend to be better able to link new concepts to prior knowledge. Conversely, students with low abilities require more intensive guidance. Students with strong prior mathematical knowledge are more capable of integrating new concepts by relating them to existing frameworks in their minds. They can connect new ideas to both superordinate (broader) and convertible (related) concepts, which supports deeper understanding and flexible problem-solving (Yang et.al., 2021). Besides that, students with lower initial mathematical abilities often struggle to make these connections independently. They may not fully understand prerequisite material, which limits their ability to grasp new concepts and apply them in different contexts (Kania et.al., 2023).

Wahyuni & Alfiana (2022) emphasized the importance of mastering basic concepts of functions, such as relations, domains, and ranges, because a weak understanding at this stage can trigger repeated errors when studying advanced materials such as inverse functions and function compositions. This shows that building a strong conceptual foundation from the start is crucial in learning mathematics. Research consistently shows that early mastery of core concepts enables students to understand, connect, and apply new mathematical ideas more effectively as they progress. Conceptual understanding allows students to see relationships between ideas, not just memorize procedures. This leads to better problem solving, critical thinking, and the ability to transfer knowledge to new situations (Hussein, 2022). Students who lack a strong conceptual base are more likely to make computational errors and misunderstand new material. Building conceptual knowledge early helps prevent these issues and supports procedural learning.

Several innovative approaches have been developed to address this challenge, one of which is the realistic mathematics learning approach. Pratiwi & Tsurayya (2023) found that this contextual approach was effective in improving student's conceptual understanding, especially in exponential function material, especially for students with auditory and kinesthetic learning styles. Thus, the selection of learning methods that are appropriate to student characteristics is an important factor in increasing engagement and learning success. Teaching that emphasizes understanding concepts rather than just procedures enables students to construct their own knowledge, address misconceptions, and improve overall performance in mathematics (Ncube & Luneta, 2025).

However, misconceptions remain a common phenomenon in mathematics learning. Sarlina (2015) identified that students often experience misconceptions in the process of classifying and applying concepts, especially in quadratic or function problems. This is not solely due to student ignorance, but also due to ineffective delivery of material and lack of reinforcement through adequate exercises. Research shows that students often develop conceptual knowledge before mastering procedures, and strong conceptual foundations help reduce errors and support procedural learning. Longitudinal and experimental studies show that many students acquire significant conceptual understanding before they master the procedures for solving mathematical problems. For example, fifth graders were found to master conceptual knowledge before procedural knowledge, and initial conceptual understanding predicted later gains in procedural skills (Nahdi & Jatisunda, 2020). Teachers and researchers emphasize the importance of teaching both conceptual and procedural knowledge, but suggest that building conceptual understanding first provides a strong base for procedural mastery and long-term mathematical competence (Hussein, 2022).

Research by Khairani & Roza (2021) has similarities with research conducted by other researchers. The similarities are in analyzing the ability to understand mathematical concepts of grade XI SMA/MA students. The difference in this study is in the material on sequences and series. The results of the study showed that students with high abilities had a very good understanding of all indicators, while students with medium and low abilities showed a fairly good understanding but experienced obstacles in accuracy and mastery of certain concepts. (Giawa et al., 2022) in their research has similarities with the research conducted by the researcher. The similarities are in analyzing the ability to understand mathematical concepts of grade XI SMA/MA students. The difference in this study is in the material on exponents and roots. The results of this study indicate that students have limited understanding of the material being taught. The researcher recommends that teachers pay more attention to differences in student abilities, provide more detailed explanations, and motivate students to understand concepts more deeply.

Yulianty's (2019) research has similarities with research conducted by other researchers. The similarities are in analyzing the ability to understand mathematical concepts of grade XI SMA/MA students. The difference in this study is in the use of the Realistic Learning Approach (RLE) compared to conventional learning methods. The results of this study showed a significant difference between the two groups after controlling for initial abilities, with students in the RLE group showing better conceptual understanding abilities. This finding confirms that the RLE approach is effective in improving student's understanding of mathematical concepts compared to conventional methods. The RLE approach is highly effective in improving student's conceptual understanding, problem solving abilities, and motivation in mathematics compared to conventional teaching methods. Its focus on real-world contexts and active learning makes mathematics more meaningful and accessible for students.

Based on the literature review that has been mentioned, previous studies have focused on various aspects of student's understanding of mathematical concepts, such as sequence and series material (Khairani & Roza, 2021), power and root forms material (Giawa et al., 2022), and the use of a realistic mathematics learning approach (Yulianty, 2019). However, these studies have not specifically examined the understanding of mathematical concepts in function material, especially in grade XI SMA, which has its complexity in teaching mathematics. In addition, although several studies have discussed student's misconceptions and difficulties in learning mathematics, not many have deeply linked teaching methods, student interactions with materials, and misconceptions that occur in the context of learning functions at the high school level.

This study offers a new contribution by analyzing student's mathematical concept understanding abilities specifically on function material in class XI of SMA Islam Sabilurrosyad Gasek Malang, using a qualitative approach based on case studies. This study not only identifies student's difficulties in understanding the concept of functions but also explores the factors that influence this understanding through interviews, observations, and tests. Thus, this study provides a more holistic picture of the dynamics of learning functions, including misconceptions that occur and how teaching methods can affect student's understanding. The results are expected to be the basis for designing more effective and relevant learning strategies to meet student's needs, which have not been widely explored in previous studies.

METHODS

This study uses a qualitative approach with a case study strategy to analyze the ability to understand the concept of numbers of class XI IPS students in the subject of Social Studies at SMA Islam Sabilurrosyad Gasek Malang in the 2024/2025 Academic Year. The case study strategy was chosen because this case study aims to examine in depth the difficulties of students in understanding the concept of numbers and recognizing the misinterpretations that occur. The subjects of the study were class XI IPS students who were selected through a purposive trial based on preliminary interviews with teachers and students, which showed that some students had difficulty understanding the concept of numbers (Assyakurrohim et al., 2022).

This trial is expected to represent the student population as a whole, so that the results of the case study can provide a clear picture of student's ability to understand the concept of numbers. The research process was carried out on November 7, 2024 at SMA Islam Sabilurrosyad Gasek Malang. Data were collected through interviews with teachers and students, classroom observations, and concept understanding tests. Interviews were conducted to explore information about the factors that influence student's understanding and the difficulties they face in learning functions. Classroom observations were used to observe student interactions with the material and the teaching methods applied by the teacher. Meanwhile, the concept understanding test aims to measure the extent to which students understand the function material and identify misconceptions that may arise in the learning process.

The combination of these three techniques allows researchers to obtain comprehensive data. The collected data is analyzed in depth to identify key themes, such as the types of difficulties faced by students, the factors that cause them, and the misconceptions that occur. The results of interviews and observations are analyzed qualitatively to find consistent patterns, while the test results are analyzed by reviewing student's answers to determine their level of understanding and identifying errors that reflect misconceptions. Data triangulation is carried out by comparing the results of interviews, observations, and tests to ensure the validity and consistency of the findings. Conclusions are drawn based on the results of the analysis, to provide recommendations to teachers to improve the effectiveness of learning functional material and help students understand the concept better (Sari, 2024).

RESULTS AND DISCUSSION

Subject with High Learning Outcomes S1

The results are analyzed by reviewing student's answers to determine their level of understanding and identifying errors that reflect misconceptions. The following are the student's answers for question number 1.

titik potong sumbu y berada pada titik y yang ke-3

Figure 1. Student S1's answer on item 1a

Based on Figure 1, the subject can identify information and understand the question instructions well, as seen from his ability to write down what is known in the question, namely that the y-axis intersection point is at the 3rd y-point.

P: What information do you get from question number 1 point a?

S1: From the question, it is known that the y-axis is located at the 3rd y-point

$$\begin{aligned} h(x) &= (f \circ g)(x) \\ &= 2x^2 - 1) + 3 \\ &= 2x^2 - 2 + 3 \\ &= 2x^2 + 1 \end{aligned}$$

$h(x)$

x	$y = 2x^2 + 1$	(x, y)
3	$2.\ 3^2 + 1 = 19$	(3, 19)
2	$2.\ 2^2 + 1 = 9$	(2, 9)
1	$2.\ 1^2 + 1 = 3$	(1, 3)
0	$2.\ 0^2 + 1 = 1$	(0, 1)
-1	$2.\ (-1)^2 + 1 = 3$	(-1, 3)
-2	$2.(-2)^2 + 1 = 9$	(-2, 9)

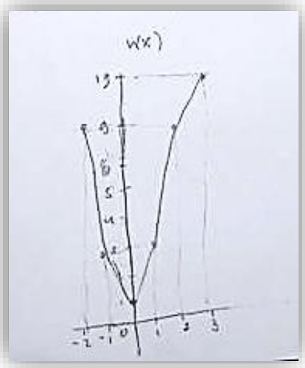

Figure 2. Student S1's answer on item 1b

The subject also demonstrated the ability to understand problems and apply mathematical formulas systematically by following the correct steps, including using the fog formula in the form of h.

P: Can you try to explain what you wrote on the answer sheet?

S1: I calculated about fog in the form of h, then I made a function table, and then described it in the form of a graph.

komposisi mempengaruhi gambar/bentuk grafiknya dari titik potong y dan gradiennya

Figure 3. Student S1's answer on item 1c

P: Then what conclusion did you get after working on the question?

S1: The composition of the table affects the intersection point, and also the gradient of the function graph

Analysis of the test and interview results revealed that S1 was able to describe the available information, understand what was asked in the question, and choose the appropriate strategy to solve the problem. In addition, the subject successfully applied the formula in stages and was able to conclude the problem-solving process carried out.

Subject with Moderate Learning Outcomes S2

Similar to subject of high learning, the responses of subject with moderate learning were also analyzed to determine their level of understanding and identifying errors that reflect misconceptions.The following are the student's answers for question number 1.

$f(x) = 2x + 3$

$g(x) = x^2 - 1$

Titik potong sumbu y ada di nomor 3

Figure 4. Student S2's answer on item 1a

Based on Figure 4, the subject can recognize the information presented in the question, as indicated by his ability to write that the y-axis intersection point is at number 3.

$$h(x) = (f \circ g)(x) = 2x^2 - 1) + 3 = 2x^2 - 2 + 3 = 2x^2 + 1$$

$h(x)$

x	$y = 2x^2 + 1$	(x, y)
3	y = 2. 3^2 + 1	(3, 19)
2	y = 2. 2^2 + 1	(2, 9)
1	y = 2. 1^2 + 1	(1, 3)
0	y = 2. 0^2 + 1	(0, 1)
-1	y = 2. $(-1)^2$ + 1	(-1, 3)
-2	y = 2.$(-2)^2$ + 1	(-2, 9)
-3	y = 2.$(-3)^2$ + 1	(-3. 19)

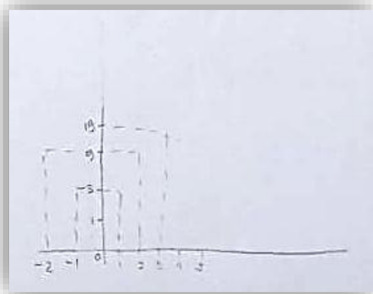

Figure 5. Student S2's answer on item 1b

The subject can also interpret and understand situations that require direct conclusions and sort out relevant information. This can be seen from his ability to create a function table and draw a function graph based on the information provided.

P: What information did you get from the question you worked on?

S2: If you want to find fog, g must come first, in the table to find f, and then draw it in the form of a graph.

komposisi mempengaruhi gambar/bentuk grafik dan titik potong y dan gradiennya

Figure 6. Student S2's answer on item 1c

P: Then what conclusion did you get after working on the question?
S1: So the value of f in the table affects the points depicted on the graph.

The test and interview analysis showed that S2 could identify information well, understand the question instructions, and recognize situations and contexts to conclude directly. In addition, S2 was able to use the right representation of the information given, choose the appropriate problem-solving strategy, apply formulas to simple problems, and draw the right conclusions from the results of the solution.

Subject with Low Learning Outcome S3

The analysis was also conducted on the answers from the The subject with low learning. The following are the student's answers for question number 1.

titik potong sumbu y ada di nomor 3

Figure 7. Student S3's answer on item 1a

Based on Figure 7, the subject also demonstrated the ability to understand the information in the question correctly, including stating that the y-axis intersection point is at number 3.

$$h(x) = (f \circ g)(x) = 2x^2 - 1) + 3 = 2x^2 - 2 + 3 = 2x^2 + 1$$

$h(x)$

x	$y = 2x^2 + 1$	(x, y)
3	$2.\,3^2 + 1 = 19$	(3, 19)
2	$2.\,2^2 + 1 = 9$	(2, 9)
1	$2.\,1^2 + 1 = 3$	(1, 3)
0	$2.\,0^2 + 1 = 1$	(0, 1)
-1	$2.\,(-1)^2 + 1 = 3$	(-1, 3)
-2	$2.(-2)^2 + 1 = 9$	(-2, 9)

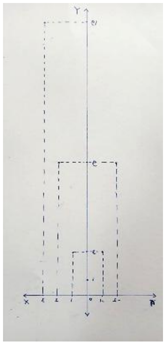

Figure 8. Student S3's answer on item 1b

The subject writes the required information clearly and uses his/her ability to understand the problem and apply mathematical formulas effectively.
P: What information do you get from the questions you work on?
S2: The composition of f and g to determine the shape of h using the fog formula, then the table to determine the points on the graph.

komposisi mempengaruhi gambar/bentuk grafiknya dan titik potong y dan gradiennya

Figure 9. Student S3's answer on item 1c

The subject has used his ability to understand the problem and use mathematical formulas.
P: Then what conclusion did you get after working on the question?
S1: Composition affects the shape of the graph; if there is no composition, you cannot determine the image and intersection point.

Based on the results of the test and interview analysis, it is known that S3 is able to identify and sort information, understand the question instructions well, and interpret situations that require direct conclusions. S3 can also use information representation well, choose appropriate problem-solving strategies, apply formulas to simple questions, and draw conclusions correctly from the problem-solving process.

The results of this study indicate that the ability to understand mathematical concepts of grade XI students on the material of functions at SMA Islam Sabilurrosyad Gasek Malang still varies, with the majority of students having difficulty understanding several important aspects of the concept of functions. Based on the results of the concept understanding test, several students were able to answer questions correctly but were unable to explain the reasons or concepts underlying their answers. This indicates a shallow or procedural understanding.

A similar finding was found by Sari and Suryadi (2018) who stated that many students were able to answer math questions correctly but did not understand the meaning of the concepts used, so they were unable to transfer knowledge to other contexts. Misconceptions found in this study, such as errors in understanding the definition of a function, distinguishing between domain and range, and drawing function graphs, are also consistent with previous findings. According to Wahyuni and Hidayat (2020), common misconceptions in function material include a mistaken understanding of the input-output relationship and a mistaken understanding of graphs as a representation of a function. These errors often stem from a limited understanding of the formal definition of a function and a lack of visual understanding of the concepts of domain and range (Nugroho & Saragih, 2017).

Interviews with teachers and students revealed several factors that caused these difficulties, such as less varied teaching methods, the dominance of expository approaches, and minimal integration of real-world contexts in learning. Teachers stated that most students were more accustomed to memorizing procedures without understanding the concept. Many students rely on rote memorization of mathematical steps, which limits their ability to flexibly apply knowledge and develop true mathematical understanding. Studies show that students often memorize procedures and formulas without grasping the concepts behind them. This is partly because textbooks and traditional instruction frequently emphasize procedural fluency over conceptual understanding, leading students to focus on repeating steps rather than making sense of the mathematics (Asmida et.al., 2018). The research by Lestari and Yudhanegara (2015), which showed that learning that only focuses on algorithms without providing space for conceptual understanding hinders student's critical and reflective thinking skills. Student's tendency to memorize procedures without understanding concepts is a widespread issue that limits mathematical reasoning and problem solving.

In addition, students also stated that technical terms were difficult to understand and functional material felt less relevant to their daily lives. The results of classroom observations reinforced these findings, where learning appeared to be teacher-centered and did not involve active discussion or exploration of concepts. Teacher-centered classrooms typically focus on content delivery, with students expected to memorize information and complete tasks for exams rather than develop skills or self-reliance. This often results in limited opportunities for students to participate, ask questions, or engage in meaningful dialogue (Muganga & Ssenkusu, 2019). Traditional methods tend to prioritize compliance and rote learning over the development of problem-solving, analytical, and independent thinking skills. Students may complete courses without gaining the ability to apply knowledge flexibly or think critically about concepts (Min et.al., 2025). Following the findings of Fitriyani and Fadhilah (2019), mathematics learning that lacks student interaction and is not contextual leads to low participation and learning motivation. Research highlights the importance of interactive and context based approaches for fostering engagement and enthusiasm in mathematics. When mathematics instruction is teacher-centered and does not involve student interaction, students are less likely to participate actively in class. Passive learning environments limit opportunities for students to explain their ideas, engage with peers, and develop deeper understanding, which in turn reduces their classroom involvement (Webb et.al., 2015). The absence of contextual learning where math is connected to real life situations leads to lower motivation. Students often perceive mathematics as abstract and irrelevant, which diminishes their willingness to engage and persist in learning activities (Lumbantobing et.al., 2024).

The combination of test data, interviews, and observations emphasizes the importance of a more interactive and contextual learning approach. Problem based learning and the use of visual or digital media that are relevant to everyday contexts can significantly improve student understanding (Wahyuni, Suryadi, & Herman, 2021). Research consistently demonstrates that combining problem-based learning (PBL) with visual or digital media relevant to everyday contexts can significantly improve student understanding. Studies show that students exposed to PBL assisted by interactive media—such as digital animations, audio-visual tools, or augmented reality—achieve higher conceptual understanding and learning outcomes compared to those taught with conventional methods (Rizqi & Setiawati, 2025). These approaches make abstract concepts more concrete and relatable, increasing student engagement and motivation. For example, integrating PBL with visual media has been shown to boost student's interest, participation, and critical thinking skills, as well as their ability to apply knowledge to real world problems (Widya et.al., 2024). Therefore, teachers are advised to develop learning strategies that emphasize conceptual understanding, not just procedures, and connect material to real applications. Teachers are strongly encouraged to develop learning strategies that prioritize conceptual understanding over rote procedural knowledge and actively connect material to real world applications. For example, using visual and intuitive methods, multiple representations, and real-life scenarios helps students build flexible, adaptive understanding and bridges the gap between theory and practice (Kunwar, 2023).

CONCLUSION

This study shows that the understanding of mathematical concepts of grade XI students on the material of functions at SMA Islam Sabilurrosyad Gasek Malang varies. Students with high abilities understand the concept well, while students with medium and low abilities still experience difficulties, especially in application and logical reasoning. Student's difficulties are influenced by monotonous learning methods, the dominance of memorization, and the lack of challenging and relevant practice questions to real life. Common misconceptions found include errors in understanding the definition of functions, domain-range, and graphs. The limitations of this study lie in the narrow scope and have not tested alternative learning methods. Therefore, it is recommended that teachers apply more interactive, contextual learning, and encourage conceptual understanding, such as the use of visual media and problem-based questions. For further research, it is recommended to involve more schools so that the results are more representative. Experimental research on the effectiveness of innovative learning methods, such as flipped classes or the use of interactive technology, is also urgently needed. Long-term evaluation is also important to see the impact of learning strategies on student's conceptual understanding in a sustainable manner.

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